Going with the flow

Water treatment plants are facing increasing legislative and operational pressures. Brian Tinham looks at some of their engineering solutions

Given that the Urban Waste Water Treatment Directive (91/271/EEC) was adopted by European member states almost 20 years ago and passed into UK law in 1995 – meaning that the UK had (theoretically) ceased all disposal of sewage sludge at sea and land-based water courses by 1998 – we might be forgiven for imagining that wastewater and effluent treatment plants were, by now, beyond reproach.

And likewise, with the passing of the European Environmental Liability Directive 2004/35/EC into British law back in 2008 – extending the existing 'polluter pays' principle to water sources, inhabited land and protected species and habitats – again, one would think that the industry must have cleaned up its act. If not, it could face serious fines for remediating environmental damage, whether caused by toxic leaks and spills, fire damage or explosions, enforced through Defra (the Department for Environment Food and Rural Affairs).

In large part, that is indeed the case. But the Environmental Liability Directive (ELD), amended in 2006 by Directive 2006/21/EC for the extractive industries, is still going through its phased introduction and continuing to place increasing requirements on member states and thus also plant operators. That's hardly surprising when you learn that this legislation only came into force in England on 1 March 2009, followed by Wales on 6 May and Scotland on 24 June of last year. And now, as we go to press, the Commission is about to present a report on the directive's effectiveness – the likely outcome of that being compulsory insurance to ensure that plant operators can meet their financial obligations where breaches are proven in court.

Three keys

That said, there are three key points. First, process plant and associated technologies continue to improve, so there are now some interesting opportunities for both municipal wastewater treatment plants and industrial effluent facilities to do better and/or cheaper – and to do so more reliably. That's particularly useful where they are asked to cope with increasing flows (due to population increase or weather extremes on municipal plants, but also growth in the industrial sector).

Secondly, the real world goes on, and engineers on water treatment plants continue to report problems, some with causes beyond their control, others absolutely within their bailiwicks. A common example of the former is industrial waste influents, which continue to arrive at wastewater treatment plants from unknown sources and threaten to push them over discharge consents. As for plants' own problems, classics include: ragging (fouling) of pumps, in turn causing inadequate flows and maintenance headaches; failed filters, leading to damaged equipment; and ageing instrumentation.

All can result in unreliable automation and, at best, energy wastage or, at worst, failed processes.

And thirdly, even if discharge consents and treatment efficiencies are not issues, with the pervasive focus on energy and carbon emissions reductions, automation equipment, such as drives and instrumentation (some relatively new, others less so), can make the required difference. And many are not just able to reduce costs and environmental impact, but can also improve plant operations (see panel, page 19).

First things first: for topical examples of plant engineering improvements, look at water softening for boiler feed pre-treatment, reverse osmosis (RO) and ion exchange demineralisation. Many plant engineers are simply not aware that even water softeners are seeing developments – one of the most recent being Elga Process Water's introduction of equipment that uses some 35% less salt than conventional plant, whether treating 1,000 or 68,000 litres per hour.

Jeremy Wakeham, Elga sales manager, says that this improvement comes about by using "an internal counter-current process". In conventional plant, he explains, the most regenerated resin is always at the top of the vessel, because that's the brine inlet (in line with all flow). However, with the new equipment, regeneration is activated from the bottom so that, during the service cycle, the last resin any water sees is the highest quality water softening resin. "With this equipment, we can achieve slightly better water quality, but also using less regenerant," says Wakeham. He concedes that the controls are slightly more complex, but insists that overall costs are still "much lower". Indeed, on smaller softeners, he makes the point that the equipment uses a multiport valve that's similar to those on conventional softeners, which also need to reverse the direction of flow for automated backwash cycles.

Next, Wakeham draws our attention to RO technology, increasingly being used where plants need alternative water sources, or want to recover process water or effluent. Beyond the obvious caveat with the latter – that RO plants neither create nor destroy contaminants and so, where tight discharge consents are concerned, care is needed on the waste side – there are clear advantages, in terms of water cost and practicality, particularly in

Pointers

- The EC is reporting on the environmental Liability Directive: managers expect mandatory insurance
- Plant technologies have improved, offering methods for better processing
- Some real world plant problems are being solved
- Drives and instruments are enabling improvements
- Even water softeners, reverse osmosis plant and ion exchange demineralisers have seen developments
- Technologies to improve sludge production look eminently transferrable

Transformational plant retrofits

Looking at real world problems on existing wastewater treatment plants, one is sludge production – mostly due to difficulties with monitoring the depth and consistency of the sludge blanket. However, two utilities in particular (Welsh Water and Severn Trent Water) are among those making significant inroads.

Welsh Water's Talybont-on-Usk 70 million litres per day treatment works is reporting an improvement in measurement accuracy, since installing Pulsar Process Measurement's Sludge Finder 2 ultrasonic level measurement instrumentation. This system, it says, is now optimising sludge thickness, which, in turn, enables production of consistent solids for onward pumping and processing.

In brief detail, the works use a conventional DAF (dissolved air flotation) process, followed by a new sludge treatment facility. This plant incorporates two picket fence thickeners, treating sludge from the DAF process, but also dirty water from two other works areas. Polyelectrolyte is dosed into the feed to aid settlement and final sludge is then removed, using positive displacement pumps. The instrumentation, which was installed by Black and Veatch, uses Pulsar's Viper self-cleaning ultrasonic transducer, which emits a sonar pulse that 'bounces' off the top of the sludge blanket. Key to its success is its echo processing software, which makes sense of the received signals, disregarding foam and plant structures.

As for Severn Trent, its development involves improvements in pump technology, and suspended solids and turbidity instrumentation, with recent trials demonstrating that the utility can produce thicker sludge in its primary settlement tank – so cutting costs and energy consumption.

STW's Mark Bryan explains: "We believed that, if we could monitor and control the settlement process through a real-time control mechanism, we would be able to produce thicker sludge, reduce operational intervention, and save the energy and costs involved with further sludge thickening prior to the sludge digestion process." The trial took place at STW's Stoke Bardolph treatment works, with instrumentation provided by Hach Lange, and the hydraulically operated ram pump and controls by EMS Industries.

Instrumentation here included a Sonatax SC sludge blanket level probe with a sister suspended solids and turbidity device, linked to EMS' control system, which manages pump operations. Thus equipped, the trial demonstrated that sludge production in excess of 5.5% solids (as opposed to the common 2–3% limit) could be reliably achieved, with good sludge blanket level stability, due to the dual action of the EMS system (varying the speed of its pump stroking to match sludge conditions) and Hach Lange's SC1000 controls (which ensure that the pump only runs when a minimum sludge blanket level has been achieved).

Says Bryan: "The new pump runs for approximately three hours each day [dependent on incoming solids loading], as opposed to eight to 16 hours with the previous system, resulting in considerable energy savings and increased process efficiency."

areas limited by mains sewage treatment capacity.

"By recovering water on site, you can reduce the requirement for piping in and out of the facility. So, if you're expanding plant production and you need more water, RO can be a good solution," says Wakeham. And prices are considerably lower than they used to be – at anything from £100,000 to £200,000 for a 5–10m³ per hour RO plant installed and commissioned – so payback can be very rapid. What's more, if you're wondering about inspection and maintenance, it's relatively simple stuff, normally involving a monthly clean of the membranes.

Better technologies

What about ion exchange demineralisation? Plant engineers with their ears to the ground will know that this type of equipment has generally fallen from favour, essentially due to the acid and caustic reagents used in the regeneration process. However, modern equipment is much more chemically efficient than its predecessors and can routinely produce high quality demineralised water, down to 1–5 micro Siemens conductivity.

In fact, Wakeham asserts that the cost of buying and running modern demineralisation equipment is now "much lower than that of RO", because it is so much less energy intensive. "If you balance all the environmental factors, you find that the effluent stream is similar to that from reverse osmosis equipment, but at two and a half times the volume – and with a higher energy requirement. That's because, instead of pumping at 2bar, RO equipment runs at 10–15 bar."

Meanwhile, another quite different water treatment plant improvement comes from Bluewater Bio, with its HYBACS (hybrid bacillus activated sludge) process and associated SMART (shaft mounted advanced reactor technology) units, originally developed in South Korea (Plant Engineer, September/October 2009, page 8). What's clever is that, compared with conventional activated sludge nutrient removal processes, HYBACS plant consumes around half the energy, yet has a 40% smaller footprint and costs typically 30% less to build. Moreover, it produces effluents with average BOD values of less than 10 mg/l from domestic sewage and is claimed to remove 98% of the BOD from concentrated industrial wastewaters.

Interestingly, it is also very well suited to upgrading existing activated sludge plants – typically retaining more than 80% of their infrastructure, so keeping costs down. With the impact of the Water Framework Directive currently being felt, that could be music to the ears of plant managers needing to consider plant upgrades in the next few years – particularly as Bluewater Bio also claims that, whereas conventional RBCs (rotating biological contactors) operate at about 2kg of oxygen per kWh, HYBACS units run at nearer 7kg per kWh – and with lower DO2 concentrations in the aeration tanks.

Latest to take the plunge with this technology is South Africa's Botleng Sewage Treatment Plant in Delmas, 60km east of Johannesburg, which is currently seeing expansion to cope with population growth.

The project, secured via Bluewater Bio's licensing agreement with Headstream Water Holdings, is for a first phase plant extension, initially designed to treat 3,500m³ per day.

Martie Janse van Rensburg, non executive chairperson of Headstream Water, says: "HYBACS technology is being recognised globally as an appealing option to alleviating issues of water shortage, providing high quality effluent treatment, reducing capital and energy costs, and maximising the use of limited footprint at treatment facilities. Its ability to remove nutrients from wastewaters, while delivering superior economics and energy savings … makes it a very suitable solution to the needs of sewage treatment in South Africa." PE

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Drive for improvement

If you're wondering how modern, conventional automation equipment can improve operations at water treatment plants, why not ask Severn Trent Water. Graham Drabble STW's capital liaison technician for the Wanlip works reckons his plant is saving around £100,000 per year on energy costs, thanks to an installation of ABB variable speed drives.

He explains that STW was suffering low flows on its dry well flow pumps, with typical rates being less than 400 litres per second, against a design requirement of 550 litres per second. As a result, under storm conditions the works was unable to achieve the rates specified under the Environment Agency's consents, without the need for supplementary temporary pumping.

Sentridge Control, part of ABB's Drives Alliance, had solved a similar problem at another of STW's works, which turned out to be caused by ragging, which was fouling the pump inlets and preventing normal operations. In this case, the installation had four direct-on-line pumps and two controlled by variable speed drives (VSDs) – one of the latter on duty and the other, assist. Reversing the pumps had allowed them to achieve higher flow rates for short periods of time, but to solve the problem permanently, Sentridge suggested installing 75kW ABB industrial drives on all the pumps, each equipped with ABB Anti-Jam software, part of its Intelligent Pump Controls.

This software performs several cleaning cycles every time the pump starts or when the VSD detects a drop in pump efficiency – each consisting of a series of rapid forward and reverse ramp-ups, and completely removing debris from around the pump volute. That, in turn, prevents rag from entering a pump and blocking it when it runs up from zero to normal operating speed.

Says Drabble: "As well as curing the flow problem, the new installation allows us to achieve our pumping requirement using only two or three pumps instead of all six, achieving an energy saving of approximately £100,000 per year."